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DOCUMENTS

DIMENSIONS NBS

The magazine of the National Bureau of Standards U.S. Department of Commerce

July 1980

HAPPY LANDINGS. See page 11.

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COMMENT

CALIBRATION, MEASUREMENT ASSURANCE, AND TRACEABILITY

This month's article on the Instrument Landing System (ILS) and the related standards and measurement support illustrates an important aspect of the mission of NBS. The Bureau's Organic Act stresses the importance of NBS maintaining national standards for physical measurements and providing the means and methods for people to make measurements consistent with those standards. Since the earliest days of its existence, NBS has provided calibration services to industry and Government to enable people to detect offsets of their measurements relative to the national standards at NBS.

The term "traceability to NBS" is often used to refer to the steps taken to realize accuracy in terms of national standards. Calibration of customer standards by NBS is one of the most familiar methods for achieving this goal. In the case of the ILS, it is clear that all concerned parties, including the Federal Aviation Administration, the avionics equipment manufacturers, and the airline companies, must have the capability of making accurate and consistent measurements of the performance of the equipment used to sense the positions of aircraft.

The measurement community seems to be becoming more sophisticated in its realization of traceability, yet there does not appear to be a universally accepted definition among the many parties requiring traceability and those who must comply with these requirements. This often leads to confusion. A recent article* points out that while regulations and contracts often specify traceability to NBS, the Bureau does not require this of anyone, nor does it have the legal authority to determine whether or not a particular laboratory's traceability is adequate. Instead, NBS provides the means by which those who need traceability for whatever reason can ensure that their measurements are accurate relative to NBS and thereby consistent with measurements by others.

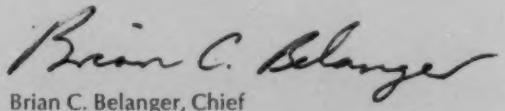
*"Traceability: An Evolving Concept", B. C. Belanger, ASTM Standardization News, Jan. 1980, p. 22.

The realization of traceability through NBS calibrations is a widely used technique. Several hundred different calibration services currently offered are described in our catalog, Special Publication 250. The SP 250 Appendix issued each June and December provides an update of the listing of services and costs with information on changes in and availability of services.

In addition to providing for traceability by calibration services, NBS also provides mechanisms for other types of applications, for example, traceability through the sale of Standard Reference Materials (SRM's) and Measurement Assurance Program (MAP) services.

While calibrations and SRM's have been available since the early days of the Bureau, MAP services have only become important during the past decade. An NBS calibration characterizes the properties of the requestor's instrument or standard, whereas a MAP service evaluates the entire measurement process in the participant's facility, thereby including sources of error due to operators, measurement methods or procedures, environmental conditions, as well as those errors associated with the instrument itself. NBS presently has MAP services available for mass, dc voltage, dc voltage ratio, electric energy (watthour meters), temperature, resistance, capacitance, and laser power and energy. A new service for gage blocks is in a trial phase, and a number of additional services are under development. User reaction to new services has been positive.

As we move into the decade of the 1980's NBS will develop and offer new calibration services to support emerging technologies and phase out those services having lower priority. Standard Reference Materials, Standard Reference Data, Calibration Services, and MAP Services constitute a visible and pervasive direct impact of the Bureau's activities on the U.S. technical community, and the essential nature of this aspect of the NBS mission is not likely to change.



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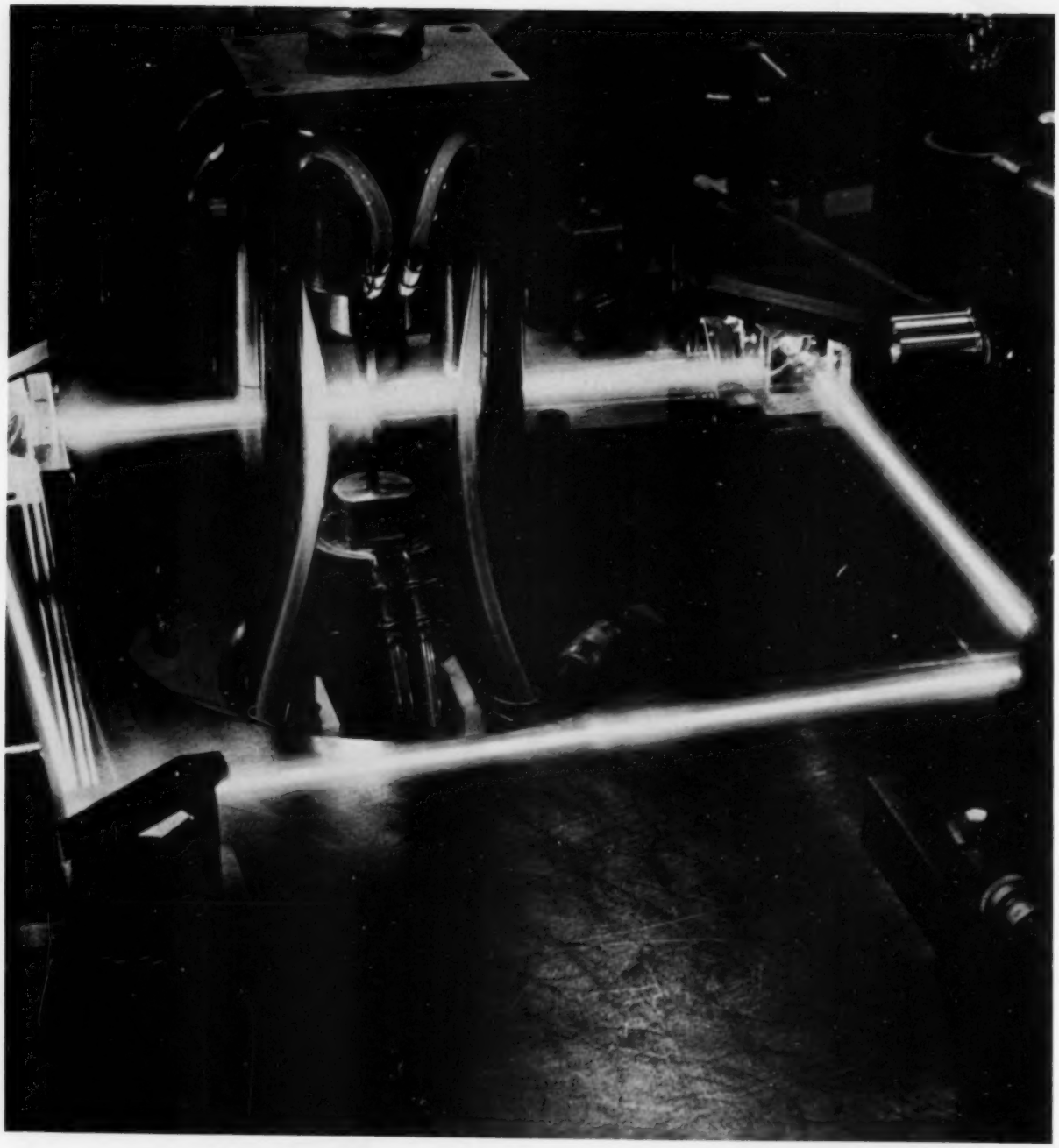
SOME LIKE IT VERY HOT!



MEASUREMENTS OF THERMO-PHYSICAL PROPERTIES AT HIGH TEMPERATURES

by Gail Porter

THE primary source of energy in America during the 1700's and 1800's was horsepower—not the four-cylinder but the four-legged variety. Fuel in the form of food was fed to the horse and work was received in return. This is essentially a heat-to-energy conversion—heat from the metabolism of food converted to energy used for work.

Since then our sources of energy have, of course, expanded and improved tremendously. And with every improvement in the production of energy has come a corresponding increase in the heat used to produce it. The internal temperature of a diesel combustion chamber reaches about 500 °C, of a turbine jet engine about 800 °C. A breeder nuclear power reactor operates above 2000 °C, while the temperatures involved in the launch of a rocket or space craft are over 2500 °C. One of the reasons for the utilization of these increasingly high temperatures lies in the second law of thermodynamics which implies that the efficiency of energy-conversion increases with increasing temperature of the heat source.

But high temperatures are destructive as well as useful. Most solids melt well below 2000 °C. Even without causing melting, high temperatures can degrade materials by promoting chemical reactions with environmental gases or by weakening the crystal structures of metals.

Future Materials Needs

Thus as new energy sources produce higher and higher temperatures, new heat-resistant materials must be found for building the engines and structures for the power of the future.

According to recent predictions by the National Research Council's Committee on High Temperature Science, there will be increasingly pressing needs for new temperature resistant materials, not only due to rising energy costs, but also because of the scarcity of some materials, such as chromium, now used in high temperature alloys. The committee emphasized that if new heat resistant materials are to be developed, scientists will first need reliable higher temperature measurements of basic thermodynamic and other physical properties.

Ared Cezairliyan couldn't agree more. Cezairliyan and his colleagues in the National Bureau of Standards (NBS) Thermophysics Division have devoted their talents to developing new measurement techniques and to applying these techniques to obtain key thermophysical properties. In particular, the behavior of various thermophysical properties of high melting point solids is sufficiently different from lower melting point materials that it has challenged NBS theorists to find new mechanisms for the dissipation of heat.

While Cezairliyan's research interests are shared by many, his methods are unique. As he says matter-of-factly, "Our lab was the first to make accurate dynamic measurements at high temperatures, and it is still the only lab in the world with broad and accurate capabilities."

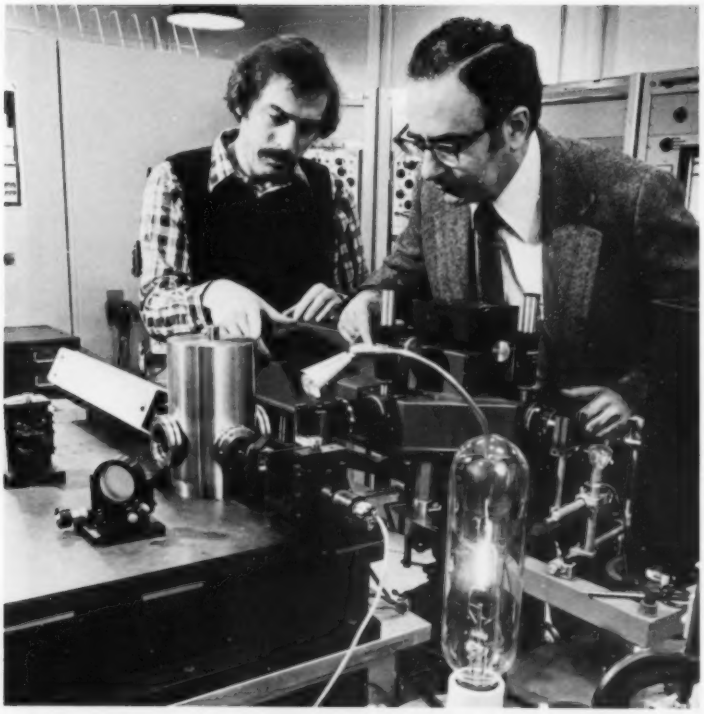
Back in the post-Sputnik era, when space loomed large in the public mind, Cezairliyan began a project funded in part by the U.S. Air Force to learn more about how metals would fare against the high temperatures of rocket propulsion and the re-entry of space vehicles through the atmosphere. Today his studies receive major funding from the Department of Energy, but his goals remain the same—to improve measurement capabilities and extend the range of high temperature thermophysical measurements.

Most experiments in this field require that the specimen under study be exposed to high temperatures for relatively long periods. The material is usually placed in a small furnace, similar in concept to an ordinary oven, and the researcher must wait several minutes to many hours for the specimen to reach a state of thermodynamic equilibrium at the desired temperature.

These so-called "steady state" methods have several drawbacks. Long exposures, especially at temperatures approaching the specimen's melting point, can cause significant evaporation. Even in experiments carried out in a vacuum or in the presence of an inert gas, high temperatures will subject the specimen to corrosion from high chemical reactivity, and changes in crystal structures will make the specimen brittle. In addition, there are some extreme cases where temperatures could rise very rapidly, for example at nuclear or magnetohydrodynamic (MHD) power plants. Slow, long-term experiments do not adequately represent such situations.

Porter is a writer and public information specialist in the NBS Public Information Division.

A laser beam is directed with mirrors to hit opposite sides of a polished rectangular metal specimen.



Archie Miiller and Ared Cezairliyan, with the millisecond dynamic measurement system. The material specimen, located within the steel chamber, is heated with a powerful pulse of electric current to temperatures between 1200 °C and 3500 °C.

Millisecond Measurements

NBS researchers have solved these problems by developing techniques to expose specimens for drastically shorter time periods. A millisecond thermophysical properties measurement system, developed by Cezairliyan in 1970 along with NBS coworkers, Malcolm Morse and Charles Beckett, uses a powerful zap of electricity (2000 amperes of direct current) to heat electrically conducting materials from room temperature to temperatures between 1200 °C and 3500 °C in less than a second.

During this short time, several instruments take 1200 measurements per second of the specimen's vital signs—quantities like temperature and absorbed power, which can then be used to calculate properties such as heat capacity, electrical resistivity, and thermal emittance. Data from the measurements are recorded with a high-speed digital data acquisition system. This system is essentially a home-made mini-computer, designed by Morse to meet the needs of this research. It is one of the first mini-computers ever built for applications in materials property measurements.

The backbone of the measurements system is a high-speed photoelectric pyrometer, a device used in measuring temperatures. The pyrometer detects thermal radiation emitted by the specimen during its rapid heating period. When referenced against an accurately calibrated tungsten strip lamp, the pyrometer will give extremely accurate readings of the temperature variations in the specimen. Because these measurements are not limited by the relatively slow speed of heat conduction, the pyrometer can detect temperature changes much faster than thermocouples used in most conventional experiments.

A fairly recent addition to the system is another high-speed instrument called a pulsed Michelson-type interferometer, which measures minute amounts of thermal expansion. As most materials are heated, their molecules begin to move faster and, on the average, farther away from one another, in most cases causing an increase in size. This property of metals is particularly critical in any structural application where expansion and contraction with heat changes can loosen joints.

Interferometers are widely used for precise size measurements, but by virtue of the very short high temperature exposures used with the dynamic measurement method, this instrument is the first one capable of detecting size changes at temperatures above 800 °C. Developed by NBS researcher Archie Miiller with Cezairliyan, the instrument makes use of light rays from a polarized helium/neon laser. The single laser beam is split into two component beams, one of which is directed with mirrors so that it undergoes successive reflections from opposite sides of a polished rectangular metal specimen, and one which serves as a reference beam. When the two beams recombine in front of a photodetector, the two light waves are "out of sync" because they have traveled different distances. The change in the amount of displacement between the two light waves tells the researcher exactly how the thickness of the specimen changes. These data are also recorded at millisecond intervals.

The "Slow Motion" Effect

By taking data frequently, Cezairliyan and his coworkers are able to get an expanded view of the specimen's response to high temperatures and thus are better able to understand its thermodynamic behavior. (An invention with analogous benefits might be the first use of sequential photos of motion, which proved what the human eye could not

be sure of—that at certain points in a horse's stride all four hooves leave the ground at once.)

Measurements taken with the millisecond system have also helped confirm what had not been proven otherwise. For years, scientists involved in steady state high temperature measurements had noticed that the heat capacities of some materials seemed larger near their melting points than the accepted theories of solids had predicted. This was particularly true for high melting point metals like molybdenum and tungsten. However, because of the inherent uncertainties in these kinds of measurements above 1700 °C, researchers couldn't be sure whether these discrepancies were real or simply the result of experimental error.

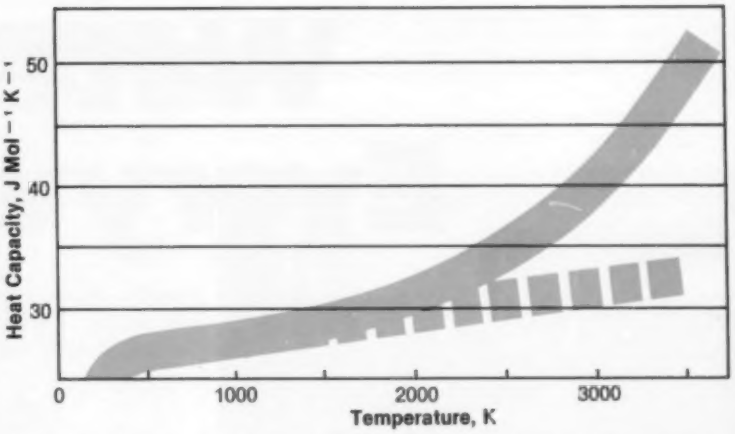
"Dr. Cezairliyan's measurements have made it quite clear," says NBS physicist Rosemary MacDonald, "that these increases in heat capacity could not be attributed to poor experimental techniques." Heat capacity measurements taken with the millisecond system show a marked divergence from theoretically predicted values, as illustrated in the accompanying graph.

MacDonald is trying to explain the discrepancy through a computer modeling technique called molecular dynamics. This technique allows a researcher to simulate the motions of molecules on a computer. On the basis of these studies, MacDonald speculates that it is possible that vacancies in the crystal arrangement of certain materials allow an extra amount of heat to be absorbed both by providing more room for molecules to vibrate, and by allowing additional crystal patterns to be set up.

With the millisecond measurement system, metal specimens can be observed at temperatures just up to their melting points. When the melting point is reached the specimen collapses into a puddle of molten metal, making further measurements impossible.

"Stop Action" Data

To overcome this limitation, NBS researchers are now designing an even faster system which will have a capability for heating the specimen to temperatures as high as 10000 °C and making measurements at the rate of about one million each second. With this microsecond system, the researcher will be able to take "stop action" data "snapshots" of the melted metal before it collapses out of the instrument's view. The time frame with this new system will be so small that the molten metal will appear to stand as a solid for several hundred microseconds.



Heat capacity measurements of tungsten, determined with the NBS millisecond measurement system (solid line), show a marked divergence from theoretically predicted values (dotted line).

While there are still a few rather sophisticated kinks to be ironed out, Cezairliyan expects the microsecond system to be fully operational within a year. New data collected with this system should yield better information on the mechanisms of melting and on the behavior of high-temperature liquid metals, which are now rather poorly understood.

Microsecond measurements will also bring the researchers a step closer toward observation of events on an atomic time scale. Real-time molecular motions occur in less than 10^{-12} second; the microsecond system will allow measurements of molecular behavior every 10^{-5} second. While there is still a wide gap between the two, there may come a time, says Harold Raveché, chief of the NBS Thermophysics Division, when the capacity of computers to handle the enormous number of calculations needed to simulate molecular motions will converge on the capacity of experiments to probe molecular behavior directly.

In other words, as computer simulation studies begin to model longer, more complicated motions, and experimental techniques take measurements faster and faster, scientists could eventually devise methods to simulate real-time molecular movements.

Such is the stuff that powerfully predictive models are made of. Models serving as blueprints for creating new materials with resistance to higher temperatures. Models suggesting ways to increase the temperature resistance of present materials. Models helping to change today's theories for producing energy more efficiently and more economically . . . into tomorrow's realities. □

Water Water Everywhere... and not a drop to spare

by Mat Heyman

IT seemed like a great idea. By installing low-flow water closets in their new 200-unit housing project in Baltimore, the developers could cut back on the supply of water needed to service the building's occupants. And who isn't in favor of water conservation?

But things didn't work out quite as expected. The developers ended up ripping out the spanking new water closets and replacing them with more water-thirsty traditional fixtures. By reducing the usual flow of water through the system, the water closets had created a major drainage problem. There simply wasn't enough water flowing through the pipes to flush the wastes completely away.

It's a problem that other builders are starting to run into and a portent of the basic obstacles which face those who seek to cut back on residential water use during the 1980's, when water conservation is expected to be a major practical and political issue.

Droughts, the lack of watershed capacity, and spiraling costs of water supply and wastewater treatment plants which accompany real estate development will heighten the interest in water conservation strategies.

That is why researchers at the National Bureau of Standards (NBS) are conducting a water conservation research program under the sponsorship of the Department of Housing and Urban Development (HUD)*. In the words of Dr. Lawrence Galowin, a senior mechanical engineer in the NBS Center for Building Technology, "the program aims to develop test data and provide engineering design methods and laboratory-based evaluation criteria which can be introduced into the building standards and codes system to encourage water conserving technologies that will perform reliably and effectively for the consumer."

Galowin, who is managing the project for the Bureau, says that HUD, state and local regulators, and the plumbing industry itself are very much interested in the NBS laboratory work, hoping that it will fill the gap that now exists between emerging water-saving products and present methods for judging their effectiveness.

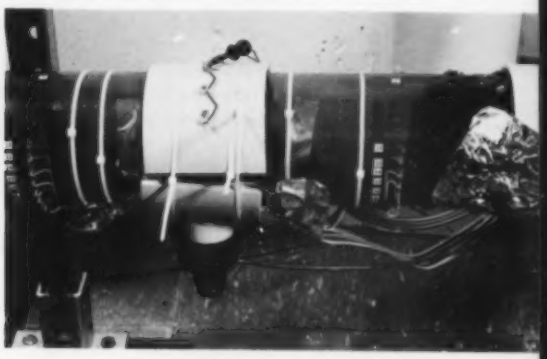
HUD is concerned about incorporating water conservation technologies into housing projects that it helps finance. The agency is looking to NBS for information about the effectiveness of certain water-saving methods and expects it to be of general

Heyman is chief of Media Liaison in the NBS Public Information Division.

**The program is sponsored by HUD's Division of Energy, Building Technology and Standards, Office of Policy, Development, and Research.*

D. Bal Mahajan and co-op student Jim James (standing) are studying the dynamics of solid waste transport mechanisms. This work will lead to new recommended design procedures and model code tables for reduced pipe sizing to accompany low-flow water closets.

This test set up allows NBS researchers to measure the velocity of solids and depth of water in a partially filled pipe.



interest to other Federal agencies responding to the Presidential directive to implement low cost water conservation practices.

Much of the impetus for water conservation is coming from the States where individual legislatures and regulatory authorities have been insisting on reduced water usage rates for particular plumbing fixtures. This poses two very distinct problems which NBS will be helping to solve. For the plumbing industry, the individualized state requirements spell trouble in terms of limiting a company's ability to sell a given product in the national marketplace. A water closet manufacturer, who may be able to sell a 19 liter (5 gallon) per flush fixture in one state, may find that a neighboring jurisdiction bans the use of new water closets with anything more than a 13 liter (3.5 gallon) per flush rate. Plumbing suppliers are worried about the patchwork of regulations that seems to be developing, much as appliance manufacturers were troubled by varying State energy efficiency standards in the 1970's.

The second major problem associated with these individual State actions to conserve water (sometimes taken under the pressure of a drought or other restrictions on local water supplies) is the partial alteration of plumbing and building codes. State codes are typically based on model codes prepared by national nongovernmental groups. What is happening is that a State may reduce the

maximum allowable flow rates for newly installed water closets, for instance, while leaving the related drainage pipe sizing requirements in the code intact. The pipe sizing standards, however, were developed for the most part on the basis of research done at NBS back in the 1940's, and they have not been substantially updated to take into account the push toward water conservation. The result could be wastewater systems for buildings that do not have proper drainage—in short, back-ups similar to those which plagued the Baltimore housing project. In this case, without the research on drainage systems and waste transport mechanisms, builders, the plumbing industry, and State and local governments simply will not have the improved system designs needed to prevent such situations.

More Objective Evaluations

One of the major goals of the Bureau's water conservation program is to perform the research and to develop the data and test evaluation procedures that will result in recommended performance standards and guidelines for entire water systems in buildings. Information from NBS tests as well as Bureau-drafted test procedures and performance standards will be provided to HUD and recommended to U.S. voluntary standards-writing organizations, which will review the results and consider them for possible incorporation. These revised standards may, in turn, serve as the basis for changes in the model plumbing codes and State versions of these codes.

That process is already underway on tests to judge the performance of water closets in removing wastes. Under contract to NBS as part of the HUD program, the Stevens Institute of Technology in New Jersey had developed improved techniques for measuring performance of these fixtures, including surface cleansing and waste removal capabilities. The test method uses polyethylene pellets and polypropylene spheres for solids as well as a fluorescent dye for liquids—which can be easily measured and reproduced—to replace the present reliance on sawdust, tobacco, and like substances which cannot be measured reliably. Recently, the new method was tentatively approved by an American National Standards Institute committee for incorporation into the current voluntary standard for plumbing fixtures.

In the same way, precise and accurate measurement methods are being developed to establish performance evaluation criteria for two-step flush water closets. These fixtures rely on selective handle operation to reduce even further the amount of water used, depending on whether solid or liquid wastes need to be flushed away. Onsite waste treatment systems, ranging from chemical toilets and septic systems to aerobic and anaerobic treatment systems, service 25 percent of the Nation's residences. NBS has examined these systems, too, and is developing performance criteria for HUD which will help ensure satisfactory operation and maintenance. "In each case, what we are trying to do," says Galowin, "is to get away from subjective evaluations by applying reproducible measurement methods and evaluation techniques."

Do low-flow showerheads do the job? Technician Michael McCall (left) and co-op student Sam Brice are shown with the water collection rig used to measure the distribution patterns of different showerheads.

Hydraulic Tests

Since bathing accounts for approximately one-third of total residential water usage, showerheads

have been obvious targets for water conservation efforts. They are also another example of the current dearth of reliable performance test methods. According to Galowin, "manufacturers now generally conduct a flow rate versus pressure test, with some other limited evaluations. There are plenty of other parameters which relate to performance and consumer satisfaction."

NBS researchers have identified other considerations which need to be factored into a reliable and valid test of hydraulic performance; these include radial water distribution (cone angle), circumferential distribution, intensity, temperature variability, spray variability, and flow rate dependence on the angle at which the shower head is connected. Working in the Bureau's plumbing research laboratory, NBS staffers have also constructed a test rig which allows them to gather this type of information and to determine the utility of the technique as a test method. The pie-shaped sectors crossing a series of rings, looking much like the "skeetball" game played at carnivals, permit researchers to measure water distribution patterns of different showerheads. The water collection rig provides a device for readily reproducible tests and is the type of equipment that manufacturers, or others with hydraulic laboratories, could be expected to fabricate at a reasonable cost if NBS recommendations for a new standard are adopted.

Consumer Choices

To make sure that Bureau recommendations derived from hydraulic tests are realistic in terms of user acceptance, a pilot field study of low flow showerheads is underway. Showerheads are being instrumented with pressure and temperature gages and will be distributed on a volunteer basis to Bureau employees in a field test to determine actual use conditions and consumer preferences.

Consumer usage patterns and preferences are, in fact, an important part of the overall NBS water conservation research program. Jacqueline Elder, a research psychologist in the Center for Building Technology, is evaluating the types of considerations which determine user acceptance or rejection of incentives used to motivate people to reduce water consumption and the effectiveness of strategies to promote its conservation. Elder is reviewing the kinds of consumer education campaigns which have been conducted to date, primarily in areas of the country that have been stricken by drought or other causes of water supply

One NBS project is to examine the discharge from dishwashers for possible re-use, for example, in water closets. Engineering technician Lynn Shorter filters "grey water" from a wash cycle as part of this work.

reductions during the past few years. Consumer feedback mechanisms—water metering and more detailed water billing, for instance—are also being examined, as are user responses to conservation-oriented water rate structures.

Elder says that her work to date suggests that "The area of incentives is not very encouraging. It seems as though a lot is being done without first knowing what has and has not been effective in the past. Also, a lot of consumer education and incentive techniques have been borrowed from energy conservation experience, and it is not clear how well they really relate to water conservation efforts."

A preliminary review of the situation has led Elder to conclude that unless there is an immediate shortage of water, individuals are not strongly motivated to conserve. Yet in crisis situations, water users cut back on consumption when they believe there is a real shortage. During such periods, in fact, Elder suggests that behavioral changes might be three to four times as effective as structural devices in lowering residential consumption, at least temporarily. They do not, however, seem to persist after the crisis has eased.

Saving Water and Energy

A longer-lasting motivation is apparently beginning to take hold. As energy costs continue to climb, consumers will undoubtedly find additional reasons for conserving water when its consumption is closely tied to energy use, as is the case of washing clothes and dishes. The relationship between energy and water consumption in these appliances has made the NBS Center for Consumer Product Technology a logical laboratory for testing water reduction possibilities for dishwashers and washing machines. Building on several years of work for the Department of Energy to draft test methods for determining the energy efficiency and operation costs of a range of consumer products—including these two worksavers—researchers at NBS have been studying the impact of water-conserving modifications on the products' performance and on drainage systems.

NBS electronic engineer Charles Gordon says, "We are trying to see if there is anything that can be done to reduce water usage which does not jeopardize the performance of dishwashers and washing machines. It is just possible," he notes, "that industry may be at the point where substantial reductions in water use have been achieved as a result of manufacturers' efforts to conserve energy, and industry may not be able to do much more about saving water." Gordon reports that NBS "will be trying to determine if the technology for these appliances is at the point where it would be uneconomical to redesign them to achieve water use reductions."

Even if these appliances will not be able to contribute much more in the way of water saving due to reduced usage rates, they may help out by serving as a supplemental means for transporting other household wastes through the drainage system. Low-flow water closets, for instance, might be combined with "grey water" systems, reusing the wastewater from later cycles of dishwashers and washing machines. NBS is studying the possibility of using grey water in this way, analyzing wastewater composition as a first step. Eventually, Bureau researchers plan to investigate the technical requirements and test methods which might be needed to assure proper performance by the still experimental grey water systems.

A small but significant part of the NBS water conservation program is designed to model the economics of water conservation strategies for the user. Dr. Stephen F. Weber, an economist with the Center for Building Technology, is working on a method for selecting the most economical and effective combination of water-conserving options open to the consumer.

"There is no single recommended combination of water-saving devices which would be economical all across the country, mostly because of diverse water rates," says Weber. As a first step, he has been reviewing 700 water rate schedules supplied by the American Water Works Association. Although still in the early stages of the project, Weber says, "One thing which seems clear is that anytime you will have energy savings associated with a reduction in water use, the money you save on energy can equal the savings on your water bill." Both benefits reinforce each other as rewards for conservation. However, they make analysis of benefits more difficult. As a result, coming up with a definitive method for selecting cost-effective water conservation alternatives will aid consumers and community water planners.

Plumbing technology has been around since outhouses were outmoded, and NBS has been involved in this field since the 1920's. Now, with the growing emphasis on conserving water, the type of research being performed at the Bureau may become nearly as much of a necessity as the plumbing itself. □

HAPPY LANDINGS

NBS Develops Standard for Instrument Landing Systems

by Fred McGehan

John Jones stared out the window at the rolling, wooded terrain below him. It was familiar territory —Connecticut—where he had been born and raised. He was coming home again. His thoughts went back in time and he spent long stretches looking out the window. There was an illness in the family, so this was not a happy occasion for homecoming. The only cheerful note was the sun, which had shone brightly during the entire morning flight from Baltimore.

He could sense the plane decelerating as it approached the Hartford airport. Only a few minutes more and he would be on the ground. Or would he? As the plane banked to the right he noticed that Hartford was completely obscured by a dense fog rolling off the Connecticut River. The aircraft would have to go into the fog to make a landing.

John was an experienced air traveler and had become quite comfortable with this form of travel, but never had he been on a plane that had to land in such pea soup. He was aware of an unusual amount of chatter around him—an indication that the other passengers were equally as nervous. He could feel his body tense as the plane completed its circle and began its final descent. Soon fog enveloped the plane and visibility was zero. John's heart raced and not a few prayers went through his mind. Suddenly he could feel the engines roar as the pilot obviously decided to abort this landing. What now, John wondered. Surely the pilot will fly on to Providence, the next scheduled stop. But the huge silver bird climbed out of the fog, circled, and came in for a second try. Again all visual references were lost as streamers of fog flew by the windows. The chatter of passengers had stopped. All must be praying, John thought. The plane continued its descent until it broke through the fog layer as the ground loomed up.

John couldn't remember any more welcome sound than the thud as the plane's tires hit the runway. What a relief. What a skillful pilot. John's legs were still a bit shaky as he descended the metal stairs and walked toward the shelter of the airport . . .

McGehan is a writer and public information specialist in the NBS Boulder Program Information Office.

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JOHN'S anxiety at landing in low-visibility conditions is natural. Thousands of other air travelers have had similar experiences. But what John didn't realize was that it was not the pilot alone who brought that big bird in. Sitting with the pilot, figuratively, were 50 years of technology—technology that was initiated by the National Bureau of Standards—technology that is still traceable to NBS.

John's pilot was relying on a sophisticated instrument landing system (ILS for short) that utilizes radio technology to guide the plane to a safe landing. Normally the pilot controls the landing phase with the aid of the ILS. However, a number of airlines are capable of landing fully automatically with the ILS signals actuating the aircraft controls. Depending on the sophistication of the ILS and related ground and airborne equipment, the pilot's decision heights (the minimum altitude from which the pilot must be able to see to land) may be 60 m (200 ft), 30 m (100 ft) or less than 30 m. Most ILS systems are in the first category and there are very few in the third category in the United States. It is at the decision point that the pilot must be able to begin to land visually or abort the landing as John Jones' pilot did on the first approach.

The development of ILS can be traced directly to war research performed by NBS in 1917. Searching for a means to detect enemy U-boats, Frederick A. Kolster, a Bureau scientist, devised a radio direction finder. As described in "Measures for Progress," a history of NBS research, the direction finder was "essentially a simple rotating coil that detected transmitted radio waves and then narrowed down the direction from which they were sent." It had an exceptionally high degree of accuracy.

By 1918 the Post Office had established airmail

NBS engineers are measuring the radio frequency emission from the localizer antenna array at Stapleton Airport (Denver). This VHF array provides horizontal guidance for landing to the pilot whose plane is equipped with an Instrument Landing System.

service between New York and Washington and was looking for a device to aid its pilots in detecting landing fields in bad weather, particularly in rain and fog. At that time there were no night flights. The Post Office Department sought the aid of NBS, and the Bureau offered two adaptations of its direction finder—one employing magnetic induction and the other a radiofrequency current. Using either system, the pilot was able to hear a signal when the plane was directly over the field. It was crude and effective only at altitudes up to 1.6 km (one mile).

After the war, NBS efforts were directed toward developing radio compasses and radio guidance systems for both ships and airplanes. The expansion of air travel from hauling mail to carrying passengers demanded instruments of greater precision. In 1929, Harry Diamond, an electronics genius on the NBS staff, invented the first visual-type radiobeacon that enabled a pilot to keep on course and know the plane's approximate position at all times. A year later Diamond's inventiveness produced a device that enabled the first landing of an airplane entirely by radio guidance.

In order to land a plane without visual reference to the ground, the pilot needs to know the plane's lateral position with respect to the runway centerline, its longitudinal position (or distance from the end of the runway), and its height. This information must be fed continuously to the pilot. Diamond achieved these objectives by placing indicators on the instrument panel to record signals from a small directional beacon, a marker beacon, and an ultrahigh frequency (UHF) radio beam. Diamond himself operated the radio in the first series of blind landing tests made in 1931. It was later adopted by the Civil Aeronautics Administration, the precursor of today's Federal Aviation Administration (FAA).

While NBS no longer develops and tests instrument landing systems, it retains a responsibility for insuring the measurement accuracy of these systems. In 1972 the FAA came to the NBS Electromagnetic Fields Division in Boulder, Colo., for help in developing an accurate standard for modulation levels of the guidance signals used in air navigation systems. The resulting instruments (a precision modulation meter and a stable amplitude-modulated signal source) are described in NBS Technical Note 1016, "A Standard for RF Modulation Factor" (September 1979).* Although the standard was de-

*NBS Technical Note 1016, "A Standard for RF Modulation Factor," is available for $3.50 from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order by stock no. 003-003-02125-3 (add 25 percent for foreign mailing).

Imagine you are an airline pilot guiding your craft and passengers into a fog-shrouded airport. These are some of the things you would hear and see:

6-11 km

Between 6 and 11 km (4 to 7 miles) away from the airport runway, the bottom one of three vertical lights on your marker beacon indicator flashes purple. At the same time you begin hearing a 400 Hz tone through your headset—the two dashes each second sound like the busy tone of a telephone receiver. This means you have passed over a radio beacon that is the start of an ILS landing—you have intercepted an imaginary point in the sky where the glide-slope path begins. You check your ILS instruments to make sure that the indicators for both vertical and horizontal position are at dead center.

800 m

At about 800 m (half a mile) from the touchdown point, the middle light on your marker beacon indicator flashes amber. You hear a series of 1300 Hz "dit-dot . . . dit-dot . . . dit-dot" tones through your headset. This means you have passed over the middle radio beacon—your altitude

60 m

is approximately 60 m (200 feet) and you must decide soon whether to continue with the landing or abort. If the runway approach lights and end of the runway are in sight, you switch from instrument to visual flying and you place the aircraft on the runway. If you cannot see the end of the runway at this point, you must apply power and either try again or proceed to an alternative airport.

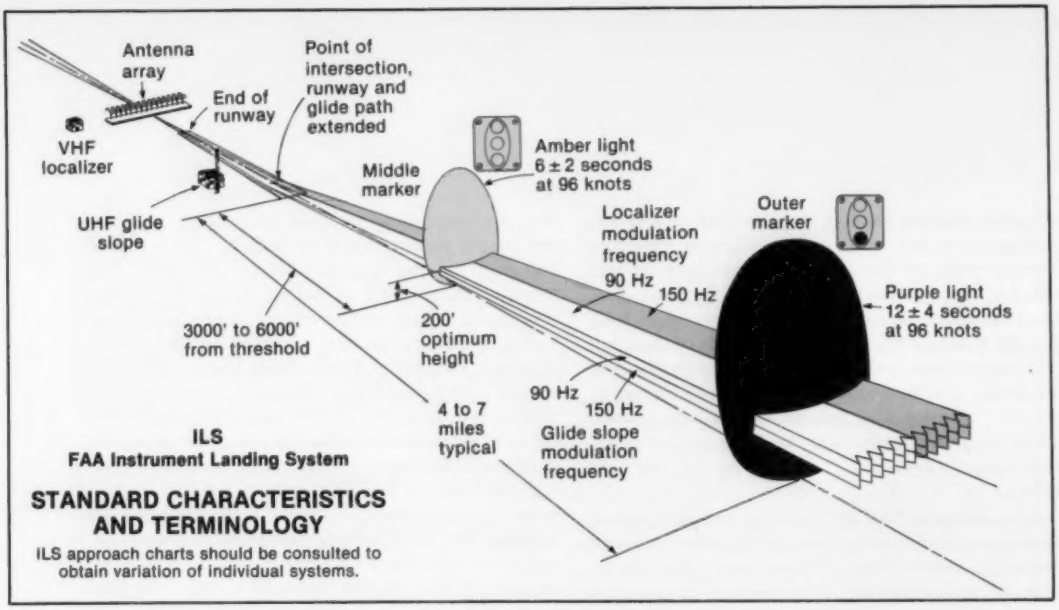
If the airport is equipped with an inner marker, between

75-450 m

75 and 450 m (250 to 1500 feet) from the runway touchdown point the top light on your indicator will flash orange. Through the earphones you will hear high-pitched 3000 Hz tones ("dit-dit-dit-dit"). You are only seconds from touchdown and you make a last check to be sure that your ILS indicators are dead center. You are coming down the middle of the glide path and heading straight for home . . .

0

You made it.


Antenna array
Point of intersection, runway and glide path extended
End of runway
VHF localizer
Amber light 6 ± 2 seconds at 96 knots
Middle marker
UHF glide slope
Localizer modulation frequency
Outer marker
90 Hz
150 Hz
Purple light 12 ± 4 seconds at 96 knots
3000' to 6000' from threshold
200' optimum height
90 Hz
150 Hz
4 to 7 miles typical
Glide slope modulation frequency
ILS
FAA Instrument Landing System
STANDARD CHARACTERISTICS AND TERMINOLOGY
ILS approach charts should be consulted to obtain variation of individual systems.

veloped primarily for use with air navigation systems, it has measurement capabilities beyond those required by such systems. Therefore, it can serve a wider variety of applications than was originally specified (for example, the precision modulation meter can calibrate the signal in a general purpose laboratory signal generator—as used for the manufacture of CB radios or equipment for the AM broadcasting industry).

Instrument landing systems are in use today at over 800 airport runways in the United States alone and possibly an equal number of runways outside this country. All types of aircraft, including commercial, private, and military, utilize the blind landing system. Although initially intended for bad weather flying, the ILS is used by all commercial craft when landing—even in good weather conditions. This provides an extra measure of safety for the estimated 745,000,000 passengers who fly on commercial aircraft worldwide each year.

The ILS used today is not so different in principle from that developed by Diamond at NBS almost 50 years ago. There are two ground-based transmitters for each runway: the localizer transmitter at the far end of the runway gives the pilot the plane's lateral position, the glide-slope transmitter off to the side of the runway provides vertical position. The descent (glide-slope) beam is focused at a three-degree angle above the horizon and, if the pilot follows the glide-slope path correctly, it will place the plane at the designated touchdown point on the runway.

Each transmitter operates at a distinctly different frequency so there is no chance of signal interference. The localizer antenna transmits a VHF signal on an assigned channel between 108 and 112 MHz; similarly, the glide-slope antenna radiates a UHF signal between 328 and 336 MHz. Each of these signals, in turn, is a carrier for two low-frequency audio signals at 90 and 150 Hz. It is the relationship between the audio signals that is the heart of the modern ILS.

If the plane is in the center of the approach path, both audio signals will have the same amplitude (wave height). The localizer indicator on the pilot's instrument panel will register dead center. If it is off the center of the approach path, say to the right, the 150 Hz tone of the localizer will have a higher voltage than the 90 Hz tone. This produces a difference in wave heights which pulls the instrument indicator to the left. Noticing this, the pilot then makes a course correction to bring the instrument indicator back to dead center. If the plane is to the left of the center of the approach path, the 90 Hz tone will have a higher voltage, producing a difference in wave heights and pulling the instrument indicator to the right. The same principle works for the vertical position indicator—if the plane's position is too high, the 90 Hz tone on the glide slope will have a higher voltage, pulling the indicator down, and if too low, the 150 Hz tone will have the higher voltage, pulling the indicator up.

In making a course correction, it is important for the pilot to be able to depend on the accuracy of the signals that are displayed on the instruments. But, how accurate are these signals? This can only be determined if there is a common accurate standard against which these signals can be measured.

This is where NBS enters the picture. It provides

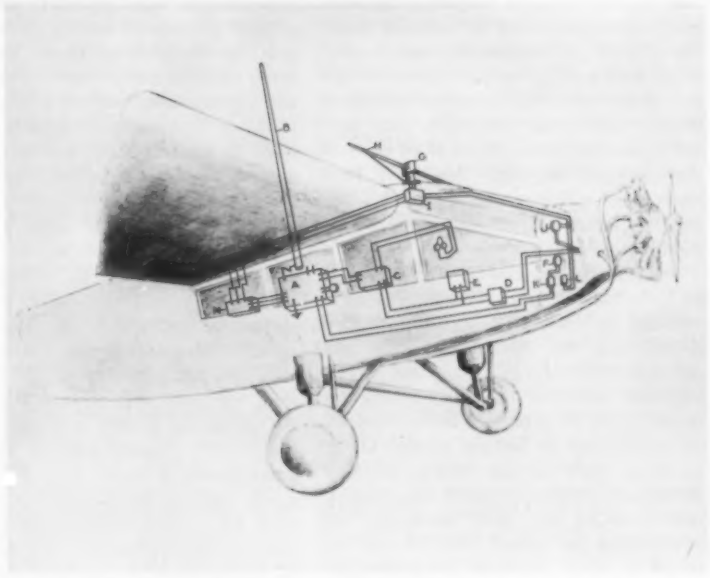
the FAA—and indirectly the pilots of all ILS-equipped aircraft—with the certainty that they can rely on the accuracy of the system. Working under contract with the FAA, the NBS developed the standard signal source and meter for measuring the amplitude of the audio tones with extreme precision. The FAA, in turn, contracted with Crescent Communication Corporation of New London, Conn., to produce modulation meters for placement in every ILS-equipped airport in the country. The accuracy of these field meters is traceable, ultimately, to the standard maintained at the NBS Boulder Laboratories.

Prior to the NBS standard, the modulation levels of ILS systems were calibrated locally but were not necessarily consistent with ILS systems at other airports. (This is reminiscent of the pre-NBS days when, for example, Brooklyn, N.Y., had four official measurements of the foot.) "We now have a common standard against which we can always measure and I'm very pleased with it," says Rial F. Sloan, an electronics engineer in the FAA's Flight Standards National Field Office in Oklahoma City.

This is the way the measurement system works in the field: The field meters are used to calibrate the ILS transmitting equipment and to test equipment used by airlines, aviation service facilities, and manufacturers to calibrate the onboard radiofrequency receivers. These receivers are calibrated in the service shop by connecting them by cable to a signal source that simulates the actual ILS signal. For example, a receiver connected to a 108 MHz test signal carrying equal-voltage 90 and 150 Hz signals should register dead center. If it doesn't, the test technician then readjusts the receiver until it does. Traceability to the standard NBS signal source is vitally important, if the technician is to be able to trust the simulated signal source as a lifeline to the ground in bad weather.

M. Gerald Arthur of the NBS Electromagnetic Fields Division notes that, according to FAA, large airliners carry several receivers so that should one or more fail, the aircraft would not be without ILS capability. In tribute to the ILS, Arthur knows of no landing accidents attributed to a failure of the ILS. Why then bother to increase the accuracy and reliability of an already-proven system? As the density of air traffic increases and more sophisticated aircraft make greater demands on the pilot's time, the chance for an accident to occur increases. "Verification of the ILS receiver will reduce that chance," Arthur says. □

A Curtiss Fledgling was equipped in 1931 with the first complete system for blind landing of an aircraft.



Sketch of complete airplane installation showing radio equipment required to make use of the first system for aiding blind landings.

Instrument panel of one of the early blind landing test planes.

ON LINE WITH INDUSTRY

NEW SURFACE SCIENCE RESEARCH TOOL DEVELOPED BY NBS AND IBM

Surface scientists are likely to find that a new research technique developed by researchers of the National Bureau of Standards (NBS) and the IBM Thomas J. Watson Research Center is a welcome improvement on some standard surface science methods.

The new technique, called angle-resolved photon stimulated desorption, or PSD, allows a researcher to "zero in" and break selected surface chemical bonds while preserving information about the angular orientation of those bonds. Angle-resolved PSD capitalizes on the fact that unlike electrons used in analogous electron stimulated desorption (ESD) systems, photons impart either all or none of their energy to the matter they strike. Thus photons of specific energies can be targeted to break only those surface bonds between preselected elements.

Initial studies by Drs. T. E. Madey and R. L. Stockbauer of NBS and Drs. J. F. van der Veen and D. E. Eastman of IBM demonstrate the utility of PSD for the desorption (release) of oxygen and hydrogen ions from the surface of a tungsten single crystal in directions determined by the orientation of surface bonds. Other methods, such as low energy electron diffraction (LEED), low and high energy ion scattering, and atom scattering, are widely used for surface structure analysis. However, these methods are limited to specimens where atoms or molecules are adsorbed on (clinging to) a surface in a systematic pattern—what surface scientists call long-range order. In addition, the analysis of data from such experiments is often time-consuming and complex. The advantage of angle-resolved PSD is that both the location and the angle of surface bonds can be determined directly, with little mathematical computation, even for specimens without long-range surface order.

As a result, one potential application for this technique lies in the chemical and structural analysis of the complex surface bonding structures of metal oxide catalysts. The vast economic importance of catalysts for the chemical, petrochemical, and synthetic fuels industries has spurred a flurry of research activity during recent years to understand more about why some catalysts out-perform others in certain applications. Surface science, or the study of how atoms and molecules behave at the edges of materials, has become an increasingly important avenue for gaining that knowledge.

Angle-resolved PSD uses a tunable synchrotron radiation source emitting "soft" x-rays (8 to 120 eV in these experiments) to selectively ionize atoms adsorbed on a surface. By locating the correct photon-energy threshold, the NBS/IBM research team found that inner shell electrons from surface atoms could be selectively excited and ejected from their orbits, causing positive ions to be subsequently released from the tungsten crystal surface. The quantitative data from their experiments have confirmed an important theory proposed recently by Drs. M. L. Knotek and P. J. Feibelman of Sandia Laboratories. The theory predicts that core holes (vacant inner electron orbitals) will produce surface ion desorption regardless of whether those vacancies are created by electron or photon excitation.

Because the photon-energy threshold for desorption of gas atoms or molecules is different for different bonding combinations, these energy differences can be used to locate the ion's original attachment site. For example, in the study of metal oxides, photon energies could be correlated with the desorption of oxygen from different elements in a composite catalyst.

Moreover, the direction that atoms or molecules move when released from a surface by photon stimulation is directly related to the angle of the surface bonds being broken. In the apparatus used for these studies, desorbing positive ions are reflected to a point behind the surface under study by a positively charged "mirror." The reflected ions are focused and amplified by an image intensifier before being displayed on a television screen. The positions of bright spots on the TV screen indicate the trajectory of the ions, and thus the angle at which the atoms were bonded to the surface before being released.

Located at the University of Wisconsin Synchrotron Radiation Facility in Stoughton, Wisconsin, this apparatus was originally designed by IBM's Eastman for measuring the energy levels of core electrons. Based on experience developing ESDIAD (Electron Stimulated Desorption Ion Angular Distributions) with NBS colleague Dr. J. T. Yates, Madey suggested that Eastman's apparatus could also be used to determine definitively whether PSD would occur from a single layer of adsorbed atoms. Madey proposed using a tungsten single crystal with an adsorbed layer of oxygen because this surface had been well documented with ESDIAD to produce three distinct ion beams.

Repetition of the surface conditions of these NBS studies at the Stoughton synchrotron facility showed that photon stimulation yielded three ion beams identical to those produced with ESDIAD, confirming the exciting potential of angle-resolved PSD for selectively breaking specific surface bonds and identifying bond angles. G. P.

STANDARDSTATUS

NEW FEDERAL STANDARD DEFINES DATA COMMUNICATIONS LINK CONTROL PROCEDURES

by Stan Lichtenstein

A standard for advanced data communications control procedures (ADCCP) has been approved by the Commerce Department and published as a National Bureau of Standards Federal Information Processing Standard (FIPS PUB 71*). Designed to reduce Federal agencies' computer networking costs, the standard defines the data link control procedures to be used by ADP equipment and services employing bit-oriented synchronous data communications links.

Under the standard, costs will be reduced through three principal improvements: (a) increasing the available alternative sources of supply for ADP equipment and services that employ synchronous data communications; (b) increasing the reutilization of such equipment; and (c) assuring required interoperability by providing a common data link control procedure for use between such equipment and services.

Written comments submitted by interested parties and other material relevant to this standard were reviewed by the National Bureau of Standards. NBS recommended approval of the standard for ADCCP as a Federal Information Processing Standard (FIPS) and prepared a detailed, supporting justification document. The Federal Register notice of May 14, 1980, announced the formal approval of the standard.

The approved FIPS adopts American National Standard X3.66-1979, Advanced Data Communications Control Procedures (ADCCP), with the following exceptions:

(1) When the address field consists of a single octet, the least significant bit (bit number 1) shall always be set to one, making the address format consistent with the extended format prescribed by section 4.3.2 of X3.66; i.e., the basic address format prescribed by section 4.3.1 of X3.66 shall not be used.

(2) The four non-reserved commands (section 7.4.5 of X3.66) and four non-reserved responses (section 7.5.5 of X3.66) shall not be specified or used.

(3) The meaning of option 11 (deleting RSET) is deleted unless the option is selected.

The provisions of this standard are effective June 13, 1980 (30 days after date of publication of the approved standard in the Federal Register). Any applicable equipment or service ordered on or after the effective date, or procurement actions for which solicitation documents have not been issued by that date, must conform to the provisions of this standard unless a waiver has been granted in accordance with the procedure described below.

Heads of agencies desiring a waiver of the requirements stated in this standard, so as to acquire applicable equipment or service not conforming to this standard, shall submit a request for waiver to the Secretary of Commerce for review and approval. Approval will be granted if, in the judgment of the Secretary, based on all available information, conformance with this standard would cause a major adverse economic or operational impact.

A request for waiver shall include a justification for the waiver, including a description and discussion of the adverse economic or operational impact that would result from conforming to this standard as compared to the alternative for which the waiver is requested. The request for waiver shall be addressed to the Secretary of Commerce, Washington, DC 20230, and labeled as a Request for Waiver to a Federal Information Processing Standard. Waiver requests will normally be processed within 45 days of receipt by the Secretary. No action shall be taken to issue solicitation documents or to order equipment or service which do not conform to this standard prior to receipt of a waiver approval response from the Secretary.

Regulations concerning the specific use of this standard in Federal procurement will be issued by the General Services Administration and become part of the Federal Property Management Regulations. The National Bureau of Standards will review this standard within 5 years after its effective date, taking into account technological trends and other factors to determine if the standard should be affirmed, revised, or withdrawn.

Further details concerning the standard may be obtained from Eric L. Scace, System Components Division, Center for Computer Systems Engineering, Institute for Computer Sciences and Technology, National Bureau of Standards, Washington, DC 20234; phone 301/921-3723.

** Either paper or microfiche copies of this Federal Information Processing Standard, including the technical specifications, may be purchased from the National Technical Information Service by ordering Federal Information Processing Standard 71 (NBS-FIPS-PUB-71), Advanced Data Communications Control Procedures. (Sale of the included technical specifications document is by arrangement with the American National Standards Institute.) Ordering information, including prices and delivery alternatives, may be obtained by contacting the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161; telephone: 703/557-4650.*

Lichtenstein is a writer and public information specialist in the NBS Public Information Division.

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Erosion of Materials, page 20
Reflectance Properties, page 22

TRACE-LEVEL ORGANIC CONSTITUENTS IN ALTERNATE FUELS

Increasing energy demand in the United States, coupled with increasing reliance on foreign sources of petroleum, has caused national concern that has resulted in a program for developing new sources of energy. The conversion of gaseous or liquid fuels and the processing of shale and tar sands promise to be new energy sources. However, one serious but largely unknown complication in developing these alternative fuels is their potentially harmful effect on man and nature. In particular, numerous organic compounds (as, for example, those identified on EPA's priority pollutant list) result from processing alternative fuels and may eventually be transported into the environment as gaseous or liquid effluents.

Willie E. May and Stephen N. Chesler, Organic Analytical Research Division, A107 Chemistry Building, 301/921-2153.

To evaluate the potential environmental effects of alternative fuels, we must analyze their base sources, industrial processing, and resulting effluents. Results of these analyses cannot be assessed adequately without knowledge of the accuracy of the analytical techniques used and data obtained.

Table 1—*Interlaboratory comparison of shale oil analysis (mg/kg).*

		Other Participating Laboratories							
Compound	**NBS**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**
pyrene	107	155	360	150	168	212	141	620	185
fluoranthene	61	102	220	80	108	104	112	380	115
benzo(a)pyrene	22	—	117	—	—	—	3.3	—	—
benzo(e)pyrene	21	—	—	—	—	—	1.3	—	—
phenol	394	392	180	—	—	—	399	—	310
o-cresol	338	350	150	—	—	—	381	2400	328

In the past, we have conducted several collaborative studies to assess the accuracy of data obtained from various trace organic analytical methodologies. The results of a recent comparison of the determinations of hydrocarbons and n-heterocyclics, by several laboratories under contract to the Department of Energy, are given in table 1. The variance among the results reported by these laboratories documents the current status of measurement in this area. One well documented method to increase the accuracy of analytical measurements uses quality assurance standards or Standard Reference Materials (SRM's).

Until recently, SRM's for environmental trace organic analyses did not exist because, for certification, they require a determination by a minimum of two totally independent methods. However, during the past year, we have developed the requisite methods for certifying a shale oil SRM. This work involved efforts by the staff of the NBS Organic Analytical Division who have expertise in gas chromatography, liquid chromatography, and mass spectrometry.

The methodology used to certify shale oil was developed over an 18-month period. Initially, we evaluated techniques for extracting the compounds of interest from a shale oil matrix. A classical acid-base extraction scheme and a high-performance liquid chromatographic fractionation procedure developed in this laboratory served as independent methods for isolating the analytes from the sample.

Table 2—*Shale oil analysis (mg/kg, 95 percent confidence level).*

	HPLC extraction with quantitation by			Acid/Base extraction with quantitation by		No extraction with quantitation by
Compound	**LC**	**GC**	**GC/MS**	**GC**	**GC/MS**	**GC/MS**
pyrene	108 ± 16	101 ± 4	102 ± 9	94 ± 10		104 ± 8
fluoranthene	53 ± 6	55 ± 6	62 ± 6	75 ± 5		58 ± 5
benzo(a)pyrene	20 ± 3		21 ± 5		24 ± 2	
benzo(e)pyrene			20 ± 6		22 ± 5	
phenol	383 ± 50	387 ± 26	416 ± 28		334 ± 63	
o-cresol	330 ± 34	334 ± 86	350 ± 16		322 ± 45	

Next, we investigated the use of gas chromatographic (GC), gas chromatographic-mass spectrometric (GC/MS), and high performance liquid chromatographic (HPLC) methods for identifying and quantifying the compounds of interest in the various fractions obtained from the isolation procedures. Direct analysis by GC/MS was also used when possible.

The data given in table 2 show that for all analytes at least two independent methods of extraction and quantitation produced results which agreed within a 95 percent confidence level. The excellent agreement among these results, compared to those obtained in an interlaboratory collaborative study, provided the basis for establishing state-of-the-art methods for trace organic analyses.

The specimen of shale oil certified is from a 150-ton retort for *in situ* simulated combustion operated by the Laramie Energy Technology Center, Laramie, Wyo. The shale is from the Mahogany Zone of the Colorado Green River formation. The stock of shale oil for the certification process (table 3) was obtained from Dr. Bruce R. Clark at Oak Ridge National Laboratory, Oak Ridge, Tenn. It was centrifuged to separate water (about 40 percent) and sludge from the oil prior to shipment to NBS. The coordination and analytical determinations of the certification process were performed by NBS scientists H. S. Hertz, S. N. Chesler, L. R. Hilpert, W. E. May, and S. A. Wise. Other members of the Organic Analytical Research Division who contributed to the certification were J. M. Brown, F. R. Guenther, P. L. Konash, R. M. Parris, and K. Richie.

The shale oil SRM, having the concentrations of phenol, o-cresol, fluoranthene, pyrene, benzo(e)pyrene, and benzo(a)pyrene certified, was issued in April as SRM 1580. Its use should greatly improve the accuracy of related environmental measurements.

Accurate measurement will provide assistance: to scientists in correctly relating health effects to levels of individual pollutants; to engineers in correctly assessing effectiveness of control technologies; to regulatory agencies in relating levels of pollution emissions with ambient air and water quality; and to the Federal Government in making correct policy decisions of cost-benefit tradeoffs concerning environmental protection, energy conservation, and economic health.

Information regarding use of SRM 1580 may be obtained from the Office of Standard Reference Materials, B311 Chemistry Building, National Bureau of Standards, Washington, DC 20234.

Table 3—*Summary of results obtained during certification of shale oil SRM 1580.*

Compound	Concentration (mg/kg)*	Numbers of Ampoules Analyzed	Sample Preparation Technique	Analytical Technique	Certified Values of Organic Constituents Concentration (mg/kg)**
fluoranthene	55 ± 5	6	Direct Injection	GC/MS	54 ± 10
	53 ± 2	9	HPLC	HPLC	
benzo(a)pyrene	20 ± 1	6	Direct Injection	GC/MS	21 ± 6
	23 ± 1	8	HPLC	HPLC	
benzo(e)pyrene	17 ± 1	6	Direct Injection	GC/MS	18 ± 8
	20 ± 3	8	HPLC	HPLC	
phenol	412 ± 35	8	HPLC	GC/MS	407 ± 50
	402 ± 4	8	Acid Base Extraction	GC	
o-cresol	386 ± 42	8	HPLC	GC/MS	385 ± 50
	384 ± 9	8	Acid Base Extraction	GC	

* Uncertainty is the standard deviation of a single measurement.

** The estimated uncertainty listed for a constituent is based on judgment and represents an evaluation of the combined effects of method imprecision, possible systematic errors among methods, and material inhomogeneity. The estimated uncertainty is intended to correspond to approximately 95 percent confidence limits.

EROSION OF BRITTLE MATERIALS BY SOLID PARTICLE IMPACT

To provide a better understanding of the micro-mechanics of erosion and other impact-related processes, NBS researchers investigated the detailed nature of damage produced by solid particles impinging on ceramics and metals. Their results, obtained by scanning and transmission electron microscopy, clearly specify the elastic-plastic nature of impacts. This information has led to the development of models which incorporate the concept of elastic-plastic fracture in describing the erosive wear of brittle materials.

Sheldon M. Wiederhorn, Bernard J. Hockey, A. William Ruff, and Lewis K. Ives, Fracture and Deformation Division, A357 Materials Building, 301/921-2901.

Erosion is a major factor in material degradation in both civilian and military applications. It results from the high velocity impact of solid particles or of liquid droplets against solids. Although each impact produces only a minute amount of damage, the cumulative effect of millions of impacts can result in appreciable loss of material from structural components. Furthermore, even the minute damage caused by the impact of a single particle can often significantly reduce the strength of brittle materials.

In many military applications, erosion shortens the lifetime and increases the cost of replacement of mechanical components. The operation of gas turbines in dusty terrains, for example, reduces turbine lifetime to one-tenth its normal value. As a result, the cost of replacing turbines in helicopters used in Southeast Asia amounted to $150 million in 1970 alone. Other examples of component degradation include: the erosion of radomes by water, ice, and dust; the damage to optical components, such as laser windows, by rain and dust; the damage to turbine and rocket components by combustion products; and the erosive thinning of helicopter blade tips by dust.

Because of their outstanding erosion resistance, ceramic materials are often used in applications where erosive wear is anticipated. Thus, castable refractories have largely replaced metals in certain high wear areas of oil refineries and are being considered for similar applications in coal gasification plants. In another application, ceramics used as nozzle vanes in experimental radial-flow gas turbines have exhibited a pronounced superiority over the standard metallic vanes in resisting erosion.

Ceramics are also used where other properties are important, but where erosion is a factor limiting reliability. In windscreens and radomes, for example, ceramics are used because of their transparency to electromagnetic radiation, but they are also able to resist erosion to maintain their integrity. Similarly, in turbine nozzles and vanes, ceramics withstand both high temperature and erosion from combustion products and dust.

These limited examples underline the need for improved erosion-resistant ceramics, the development of which could, in principle, be assisted by a better understanding of the erosion process. Recognizing this need, the Center for Materials Science has been conducting a research program to characterize the nature of mechanical damage that occurs when solid surfaces are hit by hard particles. The program has included investigations of both ceramic and metallic materials to attain as broad an understanding as possible for the erosion process. Studies have been conducted primarily through the use of the scanning and transmission electron microscopes. Erosion rate measurements have also been made in a variety of chemical environments and at temperatures ranging from room temperature to 1000 °C. The combination of techniques employed on this project has led to increased understanding of the erosion process. New elastic-plastic models of erosion are particularly applicable to brittle materials and are based on the observation that all erosion of ceramic materials, no matter how brittle, is accompanied by plastic deformation.

The earliest indication of plastic deformation during erosion of hard brittle materials (such as Al_2O_3, SiC, and Si) came from examination of individual impact sites by light microscopy. Residual plastic impressions were found to be associated with cracks that formed as a result of the impact. For soft materials such as LiF or MgO, etch-pit techniques have been used to show that dislocation slipbands are associated with impact damage or hardness impressions. These observations suggest that similar deformation accounts naturally for impact impressions in hard materials like Si, Al_2O_3, and SiC.

Using transmission electron microscopy, dislocations were observed in close proximity to the plastic impressions in all brittle materials studied (Ge, Si, Al_2O_3, SiC, MgO). The extent of deformation and the morphology of the cracks associated with the deformation were dependent on the crystal structure. MgO, an ionic crystal, exhibited the most extensive deformation at impact sites; cracks that formed (on 110 planes) in the crystal were always confined within the zone of plastic deformation. Quite the opposite behavior was observed for Si and Ge, which are covalent materials and more brittle than MgO. For these, plastic deformation was confined to the near vicinity of the impact site, but cracks propagated relatively large distances into the crystal. The behavior of SiC and Al_2O_3 was somewhat intermediate, since the extent of deformation was approximately twice the size of the residual impact impressions (figure 1). Cracks in these materials propagated beyond the deformation zone and were arrested in material that was free of dislocations.

For both ductile and brittle materials (figures 1 and 2) the density of dislocations at the contact site is so high that the crystal structure is severely strained; fruitful examination by transmission electron microscopy is not feasible. Dense tangles of dislocations result in complete scattering of the transmitted electron beam. At the edge of the impact site, the dislocation density drops abruptly to the density characteristic of the undamaged crystal. Ceramics and metals differ in appearance

because metals are able to accommodate to mechanical strains resulting from an impacting particle, whereas ceramic materials crack when subjected to high strains. As a result, crack formation is normally observed during the erosion of ceramics. In fact, it is this crack formation that usually accounts for material loss during the erosion of ceramics. Investigations of impact damage by light microscopy and scanning electron microscopy reveal the relative extents of fracture and plastic flow. Plastic deformation in ceramic materials is enhanced when particles strike target surfaces at low angles of impact. Scanning electron micrographs of the damaged surface suggest extensive plowing as a consequence of the particle impact (figure 3). At low impact angles, fracture during contact is greatly reduced. The damage sites are often free of cracks, and plastic deformation appears to be the primary mode of material removal. These observations are confirmed by transmission electron microscopy studies.

Based on NBS studies of ceramic materials, several models of erosion were developed recently to incorporate concepts of elastic-plastic fracture into erosive wear. The formation and growth of plastic zones during the impact process determine the types of cracks that are formed and, consequently, the amount of strength degradation and material loss from brittle materials during erosion.

These theories are currently being tested in the Center for Materials Science to model the lifetime of ceramic components in environments where erosion is important. Studies suggest that the hardness H and critical stress intensity factor K_c are the two materials properties that control erosion; a strong dependence of erosion rate on K_c and a weak dependence on H are observed. Although the available experimental data support the view that K_c and H (measured using dynamic loading) are independent of temperature, additional research in the Center will concentrate on determining the dependence of erosion on K_c and H and the effect of temperature.

Figure 1—*Impact site in SiC produced by 150 μm SiC particles at a velocity of 94 m/s, and an impact angle of 90°.*

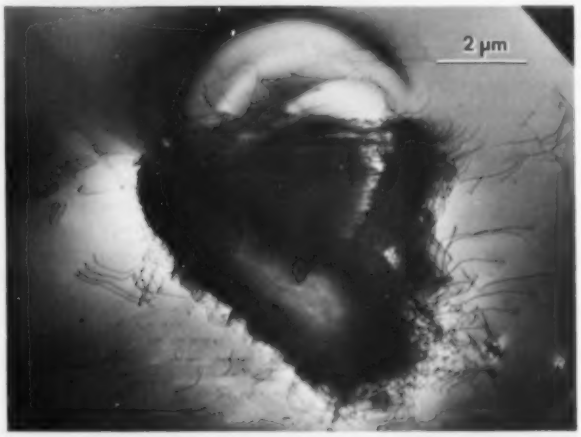


Figure 2—*Impact crater in 310 stainless steel produced by 50 μm Al_2O_3 particles at 59 m/s, impact angle 90°.*

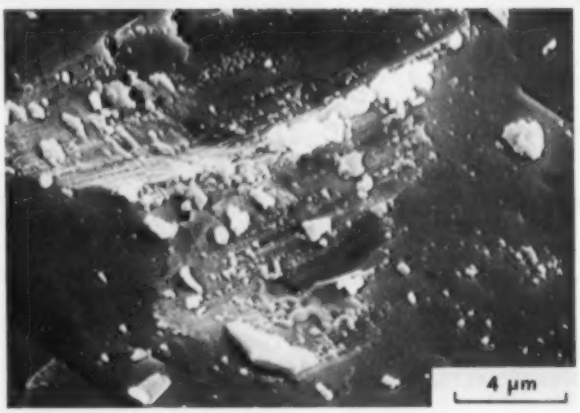


Figure 3—*Impact crater in dense Al_2O_3, 3-5 μm grain size, caused by 150 μm SiC particles at a velocity of 90 m/s and an impingement angle of 15°.*

REFLECTANCE PROPERTIES OF PRESSED TETRAFLUOROETHYLENE POWDER

Good white diffusers are used in diffuse reflectance spectrophotometry both as diffuse reflectance standards and as coatings for increasing the reflectance efficiency of integrating spheres in the measurement of diffuse reflectance (figure 1). Historically, the materials most commonly used have been magnesium oxide and barium sulfate powders or paints. Much has been written on the optical properties of these materials, and their advantages and disadvantages in spectrophotometric applications are well known. However, NBS scientists have found that some of the properties of tetrafluoroethylene powder make it attractive as a coating for integrating spheres and as a diffuse reflectance standard.

Jack J. Hsia and Victor R. Weidner, Radiometric Physics Division, A321 Metrology Building, 301/921-2791.

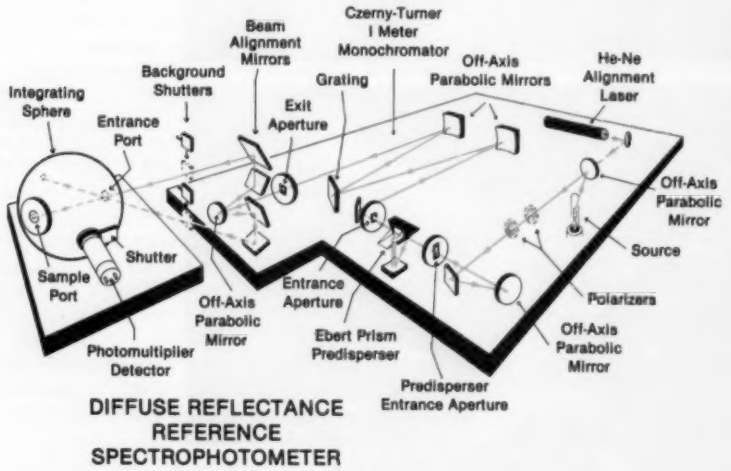
Basically, tetrafluoroethylene powder is of very fine grain size (approximately 50 micrometers), is strongly cohesive, and exhibits the highest diffuse reflectivity known for any material in the wavelength range from 200 nm to 2500 nm. Its reflectance is above 96 percent in this wavelength range and is greater than 99 percent over the wavelength range from 400 nm to 1800 nm. It is manufactured in such high purity that samples prepared from different lots over a 5-year period are found to have the same reflectance to within ±0.2 percent. Its reflectance properties are not affected by changes in humidity. Exposure to intense ultraviolet radiation causes little or no change in its reflectance in the visible and infrared regions and only slight degradation of the ultra-violet reflectance. The mechanical properties of pressed tetrafluoroethylene powder are excellent from the standpoint of its use as a coating for integrating spheres, but it is particularly susceptible to contamination before being pressed into coatings, so care must be taken in handling (figure 2).

The absolute 6°-hemispherical spectral reflectance of tetrafluoroethylene powder for sample densities of approximately 0.8 $g \cdot cm^{-3}$ has been determined by means of the NBS Reference Spectrophotometer for diffuse reflectance and the reflectance accessories used in conjunction with this instrumentation. These reflectance accessories include integrating spheres (figure 3) for measuring 6°-hemispherical reflectance and directional-hemispherical reflectance (figure 4), and a specular reflectometer which can be used to measure bidirectional reflectance in the plane of the incident beam.

The term "6°-hemispherical" refers to a geometry in which the incident beam is 6° from the normal to the sample plane and the hemispherical reflectance of that beam is measured. This is a geometry commonly used in many commercial spectrophotometers equipped with integrating spheres for measuring diffuse reflectance. The geometry allows the specular component of the reflected sample beam to be included in the hemispherical reflectance measurement, a condition that would not be possible with the sample beam normal to the plane of the sample.

Measurements of the absolute reflectance of tetrafluoroethylene powder were

Figure 1—*Pictorial diagram of spectrophotometer optical system.*



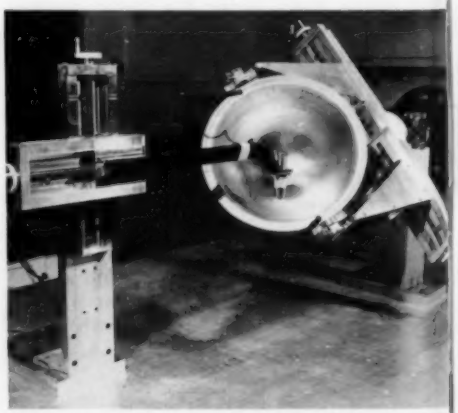


Figure 2—*Apparatus used to press powder into integrating sphere.*

made by means of the reference spectrophotometer, using the auxiliary sphere coating for the bihemispherical geometry represented by this double sphere geometry (figure 5).

Measurements of the hemispherical reflectance of tetrafluoroethylene powder as a function of angle of incidence (directional-hemispherical) are made with an integrating sphere in which the sample is suspended in the center of the sphere (figure 4). Directional-hemispherical reflectance measurements are made at angles of incidence in 5° increments between 5° and 75°. All measurements are then normalized to the value of 6° incidence.

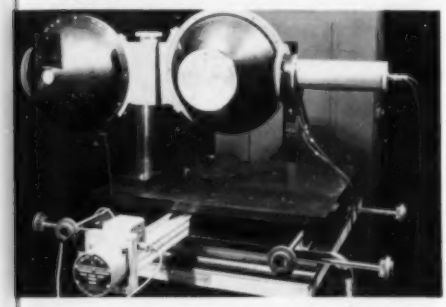
In addition to the 6°-hemispherical reflectance, measurements were also made of the bidirectional (directional-directional) reflectance of the powder for the plane of the incident sample beam. The samples were prepared with both smooth and rough finishes for this measurement. Measurements were made at 300 nm, 600 nm, and 1500 nm.

Among other optical properties of the tetrafluoroethylene powder investigated at NBS were its reflectance as a function of thickness, density, and its fluorescent properties. It was found that the maximum reflectance was obtained for densities of approximately 0.8 $g \cdot cm^{-3}$ and thickness of 6 mm or more, for the wavelength range of these investigations.

Although there is no direct evidence that tetrafluoroethylene powder itself fluoresces, there is an indication that there is some weak fluorescence associated with contaminants, possibly introduced into the powder from the plastic bag in which the material is shipped. It is known that tetrafluoroethylene powder can be contaminated by tobacco smoke and that this introduces a weak fluorescence effect. The observed excitation wavelengths are in the range from 270 nm to 290 nm with very weak emission in the range 300 nm to 330 nm. For most spectrophotometric applications where the sample is illuminated with essentially monochromatic sources, the fluorescence does not introduce a problem. No fluorescence has yet been observed for the visible or infrared spectral range.

A detailed description of the diffuse reflectance properties of tetrafluoroethylene powder and the techniques used in their determination has been prepared. An information sheet describing these properties and techniques and tabulating the results is available from the authors.

Figure 3—*Integating sphere for 6° directional-hemispherical reflectance with specular component included.*



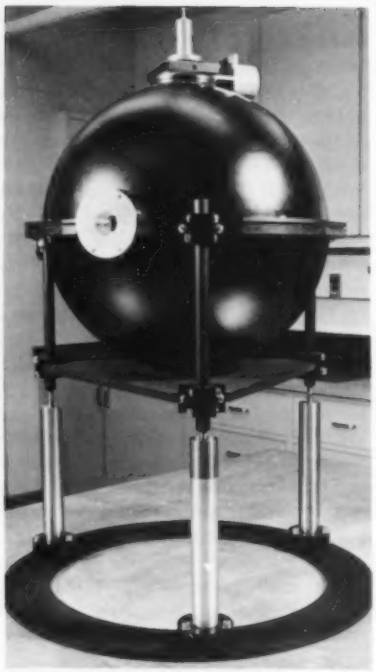


Figure 4—*Integrating sphere for measuring relative directional-hemispherical reflectance as a function of angle of incidence.*

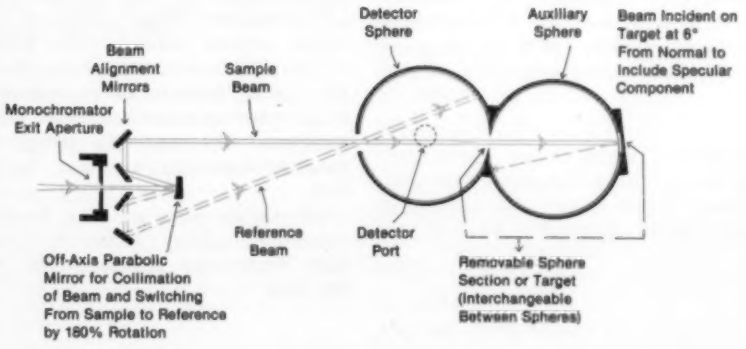

Detector Sphere
Auxiliary Sphere
Beam Incident on Target at 6° From Normal to Include Specular Component
Beam Alignment Mirrors
Sample Beam
Monochromator Exit Aperture
Reference Beam
Detector Port
Off-Axis Parabolic Mirror for Collimation of Beam and Switching From Sample to Reference by 180% Rotation
Removable Sphere Section or Target (Interchangeable Between Spheres)

Figure 5—*The auxiliary sphere system for determination of an absolute reflectance scale.*

CONFERENCES

For general information on NBS conferences, contact JoAnn Lorden, NBS Public Information Division, Washington, DC 20234, 301/921-2721.

NATIONAL CONFERENCE OF STANDARDS LABORATORIES SYMPOSIUM

A workshop and symposium will be held September 22-25, 1980, at NBS in Gaithersburg, Md. The objective of the meeting will be to provide up to date information on the issues facing standards and calibration laboratories. Professional metrology managers are becoming increasingly concerned with such topics as measurement quality to assess compliance with government regulations, to increase industrial productivity, and to ensure compliance of products with specifications. The task is becoming increasingly difficult as complex new instrumentation and challenging measurement accuracy requirements proliferate. At the same time, pressures exist on management to minimize expenditures and personnel for calibration and measurement activities and yet manage equipment inventories as efficiently as possible.

The National Conference of Standards Laboratories (NCSL) is a continuing, nonprofit laboratory-oriented organization to promote cooperative efforts toward solving the common problems faced by standards laboratories in their organization and operation. It was established in 1961 under the sponsorship of the academic, scientific, industrial, commercial, and governmental laboratories concerned with the measurement of physical quantities and calibration of standards of practice. It provides liaison with technical societies, trade associations, and educational institutions interested in these activities.

Additional information is available from: NCSL Secretariat, National Bureau of Standards, Radio Building, Room 4001, Boulder, CO 80303, 303/499-1000, ext. 3244, or Dr. Brian Belanger, Office of Measurement Services, NBS, B362 Physics Building, Washington, DC 20234, 301/921-2805.

CONFERENCE ON FIRE RESEARCH STUDIES

Combustion toxicology, human behavior in fires, hazard analysis, fire detection and suppression, and fire testing are among the topics to be spotlighted October 22-24, 1980, at the Fourth Annual Conference on Fire Research and the National Bureau of Standards in Gaithersburg, Md.

The yearly meeting permits those working on projects for the NBS Center for Fire Research to interact with others in the fire community. The conference will include overviews of each of the major applied programs carried out in the Center, the Federal Government's primary fire research laboratory. A key part of the meeting will be presentations by the nearly twenty research groups at universities and other organizations funded by the Center's Extramural Research Program.

The 1980 conference will emphasize more of the applied aspects of fire research; last year's meeting featured more of the basic aspects.

For further information on registration details, contact Ileana Martinez, Center for Fire Research, NBS, B226 Building Research Building, Washington, DC 20234, 301/921-3771.

COMPUTER NETWORKING SYMPOSIUM

The 1980 Computer Networking Symposium will be held at the National Bureau of Standards in Gaithersburg, Md., on December 10. "Focus on Office Automation" will be the theme of the symposium, sponsored by the Technical Committee on Computer Communications in the Institute of Electrical and Electronics Engineers (IEEE) Computer Society and the NBS Institute for Computer Sciences and Technology.

The symposium will highlight papers of a tutorial nature, which describe practical experiences or research dealing with office systems, office system components, and interconnecting computer networks. Tentative topics include:

- communication networks
- electronic mail
- text processing systems
- document distribution
- local area networks
- records management
- system architectures
- distributed data base

All papers will be reviewed by the program committee and a Best Paper Award will be presented at the symposium. Papers accepted for presentation will be published in the symposium proceedings.

Technical Program Chairperson is Frank Brignoli, with the Executive Office of the President. Other symposium committee officers serving with Brignoli include: Conference Chairperson, Dr. Ira W. Cotton, Booz-Hamilton and Allen, Inc; Conference Vice-Chairperson, Robert Rosenthal, NBS; and NBS Liaison and Local Arrangements, Robert E. Toense, NBS.

For further information on local arrangements contact Robert E. Toense, B226 Technology Building, NBS, 301/921-3516.

CONFERENCE CALENDAR

*August 6

5TH ANNUAL NBS-NCSBCS JOINT CONFERENCE ON INNOVATION AND REGULATORY ISSUES—TECHNICAL SEMINAR ON SOLAR ENERGY AND ENERGY CONSERVATION, Denver, CO; sponsored by NBS and NCSBCS; contact: Sandra A. Berry, B226 Building Technology, 301/921-2689.

August 14-15

ASME SYMPOSIUM ON CRITICAL MATERIALS AND FABRICATION ISSUES, St. Francis Hotel, San Francisco, CA; sponsored by NBS and ASME; contact: Jeffery Fong, A302 Administration Building, 301/921-2631.

*September 18-19

SYMPOSIUM ON INFORMATION RESOURCE MANAGEMENT (IRM), NBS, Gaithersburg, MD; sponsored by NBS and OPM; contact: Sara R. Torrence, A640 Administration Building, 301/921-2721.

September 22-24

NATIONAL CONFERENCE OF STANDARDS LABORATORIES, NBS, Gaithersburg, MD; sponsored by NBS and NCSL; contact: Brian Belanger, B362 Physics Building, 301/921-2805.

September 29-October 1

CERAMICS AS ARCHAEOLOGICAL MATERIAL, NBS, Gaithersburg, MD; sponsored by NBS and Smithsonian Institution; contact: Alan Franklin, A355 Materials Building, 301/921-2901.

*October 6-7

REFRIGERATION FOR CRYOGENICS SENSOR AND ELECTRONICS SYSTEM, NBS, Boulder, CO; sponsored by the International Institute of Refrigeration Commission A 1/2, Office of Naval Research, Naval Research Laboratory, Cryogenic Engineering Conference, and NBS; contact: Sandy McCarthy, Room 1237, Electromagnetic Technology Division, 303/497-3988.

October 7-9

COAL CONVERSION, NBS, Gaithersburg, MD; sponsored by NBS and DOE; contact: Samuel Schneider, B308 Materials Building, 301/921-2894.

*October 16-17

INTERNATIONAL MACHINE TOOL TASK FORCE CONFERENCE, McCormick Inn, Chicago, Illinois; sponsored by USAF Wright Aeronautical Laboratories with the cooperation of NBS; contact: Robert Hocken, B104 Metrology Building, 301/921-2216.

*October 22-24

FOURTH ANNUAL CONFERENCE ON FIRE RESEARCH, NBS, Gaithersburg, MD; sponsored by NBS; contact: Ileana Martinez, B226 Building Research Building, 301/921-2689.

*October 23

WORKSHOP ON CONFERENCE MATERIALS FOR ORGANIC NUTRIENT MEASUREMENT, NBS, Gaithersburg, MD; sponsored by NBS; contact: Dr. Sam Margolis, A367 Chemistry Building, 301/921-2867.

December 10

COMPUTER NETWORKING CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS and IEEE; contact: Robert Toense, B226 Technology Building, 301/921-3516.

1981

*MARCH 17-18

SECOND CONFERENCE ON CONSUMER PRODUCT STANDARDS, NBS, Gaithersburg, MD; sponsored by NBS and ASTM; contact: Walter Leight, 111 EM Building, 301/921-3750.

April 6-10

6TH INTERNATIONAL SYMPOSIUM ON NOISE IN PHYSICAL SYSTEMS, NBS, Gaithersburg, MD; sponsored by NBS and the Catholic University of America; contact: Robert J. Soulen, B128 Physics Building, 301/921-2018.

*April 30-May 1

NATIONAL ROOFING TECHNOLOGY CONFERENCE, NBS, Gaithersburg, MD; sponsored by NBS and NRCA; contact: Robert Mathey, B348 Building Research Building, 301/921-2629.

June 8-12

SECOND INTERNATIONAL CONFERENCE ON PRECISION MEASUREMENTS AND FUNDAMENTAL CONSTANTS, NBS, Gaithersburg, MD; contact: Barry N. Taylor, B258 Metrology Building, 301/921-2701.

*June 15-19

INTERNATIONAL JOINT CONFERENCE ON THERMOPHYSICAL PROPERTIES, NBS, Gaithersburg, MD; sponsored by NBS, ASME, and Purdue University; contact: A. Cezairliyan, Room 124 Hazards Building, 301/921-3687

*September 14-16

SECOND INTERNATIONAL CONFERENCE ON THE DURABILITY OF BUILDING MATERIALS AND COMPONENTS, NBS, Gaithersburg, MD; sponsored by NBS, ASTM, NRC of Canada, International Council for Building Research Studies and Documentation, International Union of Testing and Research Laboratories for Materials and Structures; contact: Geoffrey Frohnsdorff, B348 Technology Building, 301/921-3458.

* *New Listings*

PUBLICATIONS

ECONOMIC EVALUATION IN BUILDING TECHNOLOGY

*Marshall, H. E., and Ruegg, R. T., Efficient Allocation of Research Funds: Economic Evaluation Methods With Case Studies In Building Technology, Nat. Bur. Stand. (U.S.), Spec. Publ. 558, 56 pages (Dec. 1979) Stock No. 003-003-02132-6, $2.50.**

Public and private administrators of research programs are concerned with maximizing the payoffs from their research investments by allocating their limited budgets more efficiently. Benefit-cost, rate-of-return, payback, and other evaluation methodologies are examined for their usefulness in helping administrators to decide whether to accept or reject research projects leading directly to applications, to plan the scale of these research projects, and to identify priorities among alternative research investments, all of which may be profitable. Data needs for applying these evaluation methodologies are outlined. The net-benefits and rate-of-return methodologies are applied to two case studies involving research in the Center for Building Technology (CBT) of the National Bureau of Standards. The first deals with heavier asphalt shingles for roofing, and the second deals with reduced-sized venting in plumbing. The case studies show high payoffs in these two areas of research, both for society as a whole and for CBT's contribution in undertaking the research

Recommendations from the study are that research funds be allocated on the basis of anticipated payoffs, determined through these evaluation techniques, and that benefit and cost data for evaluating new technologies be collected.

COLOR SCIENCE CONTRIBUTIONS

Judd, D. B., Contributions to Color Science, Nat. Bur. of Stand. (U.S.), Spec. Publ. 545, 760 pages (Sept. 1979) Stock No. 003-003-02126-1, $14.

The National Bureau of Standards has issued a collection of papers written by color scientist Deane Judd (1900-1972). During his 43 years at the Bureau, Judd made monumental contributions to the science of colorimetry.

Fifty-seven papers, selected from over 200 articles Judd had written during his career, are included in the voluminous publication, *Contributions to Color Science*. "The Computation of Colorimetric Purity," the first article in the collection, historically marks his entrance into the field of colorimetry when he began working at the Bureau in 1926. Two milestone reports that helped advance the field of colorimetry are also included in the collection: "The 1931 ICI Standard Observer and Coordinate System for Colorimetry" introduced colorimetry into American industry and "A Maxwell Triangle Yielding Uniform Chromaticity Scales" (1935) is the theoretical basis from which all color scientists work to determine how people perceive color.

Other selected reports in the 760-page collection include Judd's pioneering discoveries on measuring and specifying color, spectrophotometry, color appearance and spacing, and color vision. The publication also covers Judd's lasting contribution—naming colors systematically, chromatic adaptation, camouflage, and color rendering.

Each article in the collection is introduced by a paragraph to explain terms that may be unfamiliar to the reader who was not involved with color research at the time Judd wrote the article. In addition, some of the introductory paragraphs highlight international agreements that have been based on Judd's work. Thus, *Contributions to Color Science* is informative and instructive as well as a tribute to the internationally recognized authority on color.

Besides the 57 selected articles, an extensive list of all works written by Judd also appears in the publication.

FLAMMABILITY CRITERIA FOR TRANSFORMER DIELECTRIC FLUIDS

Gann, R. G., Development of Flammability Criteria for Transformer Dielectric Fluids, for sale by the National Technical Information Service, Springfield, VA 22161, $7, order by #PB 80-163777.

Fire safety criteria for electrical insulating fluids used in transformers are examined in a new publication by the NBS Center for Fire Research. Using the physics of fluid ignitability, combustion, and extinction, the study explains the inadequacy of the current fire code and standard test methods and develops test-method concepts to be used in identifying and achieving standards of fire safety. The Department of Energy sponsored the study.

The research, led by Dr. Richard Gann, was prompted by the Environmental Protection Agency's ban on the use of polychlorinated biphenyls (PCB's)—possible cancer causing chemicals which had commonly been used as dielectrics (insulators) in electrical transformers. Manufacturers have been faced with a need to replace PCB's with a substitute fluid, and no operational fire safety criteria have been developed.

Analyzing the results of tests at the Factory Mutual Research Corporation and other locales, as well as at NBS, *Development of Flammability Criteria for Transformer Dielectric Fluids* suggests the use of flexible, (performance-based) criteria for transformers, depending on their use and location.

** Publications cited here may be purchased at the listed price from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign: add 25%). Microfiche copies are available from the National Technical Information Service, Springfield, VA 22161. For complete listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, DC 20234.*

RADON IN BUILDINGS: ROUND TABLE PROCEEDINGS

Collé, R., Radon in Buildings, Nat. Bur. Stand. (U.S.), Spec. Publ. 581, 84 pages (June 1980) Stock No. 003-003-02196-2, $3.75.

The proceedings of a round table discussion of radon in buildings have been published by the National Bureau of Standards. The meeting at NBS June 15, 1979, brought together four dozen participants with diverse interests in radiation protection, radiation measurements, and building technology. The round table was held as a forum for the exchange of information on the subject and to draw attention to some of the problems and research needs.

During the past few years, increased attention has focused on potential health hazards of radiation exposure due to radon in buildings or building sites. Studies have indicated that indoor concentrations of radon and its radioactive-daughter products are frequently higher than outdoor concentrations. There is also an increasing interest in energy conservation in buildings, and the strategies which may result in elevated radiation levels, such as reducing air exchange rates.

Sponsored by the NBS Center for Radiation Research and the Center for Building Technology, the discussions covered sources and pathways of radon in buildings, diffusion and interaction properties and distribution of daughter products, biological and health effects, adequacy of measurement methods, and strategies to minimize or control indoor levels of radon (such as increased ventilation and selection and treatment of building materials).

PUBLICATIONS LISTING

Acoustics and Sound

Flynn, D. R., Voorhees, C. R., and Yaniv, S. L., Highway Noise Criteria Study: Traffic Noise Data Base, Nat. Bur. Stand. (U.S.), Tech. Note 1113-1, 381 pages (Apr. 1980) Stock No. 003-003-02169-5, $8.

Atomic and Molecular Studies

Willemot, E., Dangoisse, D., Monnantuiel, N., and Bellet, J., Microwave Spectra of Molecules of Astrophysical Interest. J. Phys. Chem. Ref. Data 9, No. 1, 59-160 (1980).

Computer Science and Technology

Amer, P. D., Computer Science and Technology: Application of Measurement Criteria in the Selection of Interactive Computer Services, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-58, 90 pages (Apr. 1980) Stock No. 003-003-2174-1, $4.

Lyon, G. E., Ed., Using ANS FORTRAN, Nat. Bur. Stand. (U.S.), Handb. 131, 106 pages (Mar. 1980) Stock No. 003-003-02165-2, $4.25.

Electromagnetic Metrology

Danielson, B. L., An Assessment of the Backscatter Technique as a Means for Estimating Loss in Optical Waveguides, Nat. Bur. Stand. (U.S.), Tech. Note 1018, 88 pages (Feb. 1980) Stock No. 003-003-02160-1, $3.75.

Franzen, D. L., and Day, G. W., Measurement of Optical Fiber Bandwidth in the Time Domain, Nat. Bur. Stand. (U.S.), Tech. Note 1019, 72 pages (Feb. 1980) Stock No. 003-003-02161-0, $3.75.

Kenney, J. M., Modulation Measurements for Microwave Mixers, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-16, 86 pages (Feb. 1980) Stock No. 003-003-02154-7, $3.75.

Sreenivasia, I., Chang, D. C., and Ma, M. T., Characterization of Electrically Small Radiating Sources by Tests Inside a Transmission Line Cell, Nat. Bur. Stand. (U.S.), Tech. Note 1017, 68 pages (Feb. 1980) Stock No. 003-003-02157-1, $3.50.

Energy Conservation and Production

Marshall, H. E., and Ruegg, R. T., Simplified Energy Design Economics: Principles Applied to Energy Conservation and Solar Energy Investments in Buildings, Nat. Bur. Stand. (U.S.), Spec. Publ. 544, 54 pages (Jan. 1980) Stock No. 003-003-02156-3, $3.50.

Engineering, Product and Information Standards

Channel Level Power Control Interface, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIBS PUB) 61, 17 pages (1979).

Operational Specifications for Magnetic Tape Subsystems, Nat. Bur. Stand. (U.S.), Fed Info. Process. Stand. Publ. (FIBS PUB) 62, 39 pages (Feb. 1979).

Walkowicz, J. L., Counties and County Equivalents of the States of the United States and the District of Columbia, Nat. Bur. Stand. (U.S.), Fed. Info Process. Stand. Publ. (FIBS PUB) 6-3, 39 pages (1980).

Measurement Science and Technology Policy and State-of-the-art Surveys

Debelius, J. R., NBS Staff Participation in Outside Standards Activities, 1979 Highlights, Nat. Bur. Stand. (U.S.), Spec. Publ. 573, 64 pages (Mar. 1979) Stock No. 003-003-02176-8, $3.50.

Shorten, F. J., Ed., NBS Reactor: Summary of Activities July 1978 to June 1979, Nat. Bur. Stand. (U.S.), Tech. Note 1117, 236 pages (Apr. 1980) Stock No. 003-003-02170-9, $6.

Properties of Materials Electronic, Magnetic, and Optical

Feldman, A., Basic Optical Properties of Materials Summaries of Papers, Nat. Bur. Stand. (U.S.), Spec. Publ. 574, 252 pages (May 1980) Stock No. 003-003-02173-3, $6.50.

Properties of Materials Structural and Mechanical

Black, S., and Hubbard, C. R., Accuracy in Powder Diffraction, Nat. Bur. Stand. (U.S.), Spec. Publ., $67, 553 pages (Feb. 1980) Stock No. 003-003-02153-9, $9.

Standard Reference Data

Li, H. H., Refractive Index of Alkaline Earth Halides and its Wavelength and Temperature Derivatives, J. Phys. Chem. Ref. Data 9, No. 1, 161-290 (1980).

Martin, W. C., and Zalubas, R., Energy Levels of Magnesium, Mg I through Mg XII, J. Phys. Chem. Ref. Data 9, No. 1, 1-58 (1980).

Standard Reference Materials

Mavrodineanu, R., and Baldwin, J. R., Standard Reference Materials: Metal-on-Quartz Filters as a Standard Reference Material for Spectrophotometry—SRM 2031, Nat. Bur. Stand. (U.S.), Spec Publ. 260-68, 116 pages (Apr. 1980) Stock No. 003-003-02167-9, $4.25.

NEWS BRIEFS

CORROSION OF STEEL IN CONCRETE. In a study for the Federal Highway Administration, NBS researchers are developing a nondestructive field instrument to measure the corrosion rate of steel in concrete slabs. The goal of this work is to provide the techniques and instrumentation necessary to monitor the corrosion of reinforcing steel in bridge decks. The researchers have correlated corrosion rates determined by several electrochemical polarization techniques with measurements of actual metal weight loss and have designed a minicomputer system to take polarization measurements. Chemical processes affecting the corrosion of steel in concrete have also been studied.

SATELLITE ANTENNA MEASUREMENT COMPLETED. Researchers in the NBS Center for Electronic and Electrical Engineering in Boulder have demonstrated that the Bureau's Earth Terminal Measurement System (ETMS) can be used to measure the noise of an 11.3 meter antenna. The ETMS measured antenna gain/system noise temperature (G/T) at three frequencies simultaneously. This type of accurate noise measurement is needed since the information carrying capacity of a terminal is directly related to its noise.

DETECTING WELD CRACKS WITH ULTRASONIC DIFFRACTION. The use of ultrasonic diffraction for locating crack-like defects in welds is described in a new report issued by the NBS Office of Nondestructive Evaluation. The purpose of this work was to produce a practical and economical ultrasonic technique capable of providing reliable crack size information, particularly for pipeline welds. As part of this study, optimum test conditions for the diffraction method were established using a series of low carbon steel test specimens with narrow slits. Defect Characterization and Dimensioning of Cracks in Welds by the Ultrasonic Diffraction Method (NBSIR 80-1983) is available for $5 from the National Technical Information Service, Springfield, VA 22161. Order by #PB 80-161755.

BUREAU'S TIME AND FREQUENCY SERVICES DESCRIBED. NBS Time and Frequency Dissemination Services (SP 432) offers a detailed description of the time and frequency dissemination services of NBS. The 16-page publication provides a brief history of the Bureau's services and discusses the broadcasts available from radio stations WWV and WWVB in Fort Collins, Colo., and from WWVH in Kauai, Hawaii. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402. Order by SD No. 003-003-02105-9 for $1.50.

BUILDING CODES DO NOT IMPEDE SOLAR PROJECTS. Existing building codes do not present barriers to the installation and acceptance of solar heating and cooling systems, according to an NBS report. NBS has also concluded that code officials need additional training and better back-up material in order to evaluate systems and properly inspect the installations. The NBS report contains data and information gathered from builders and building code officials during a 3-year period of the ongoing Solar Residential Demonstration Program. The Analysis of Code Related Responses from the Solar Demonstration Program (NBSIR 79-1957) is available from the National Technical Information Service, Springfield, VA 22161 for $11. Order by #PB 80-153-968.

NEXT MONTH IN

DIMENSIONS/NBS

We are all familiar with the term "moonlighting," but what is "daylighting"? In the next issue of DIMENSIONS/NBS learn what NBS and industry researchers are discovering with regard to application of this concept to building design.

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